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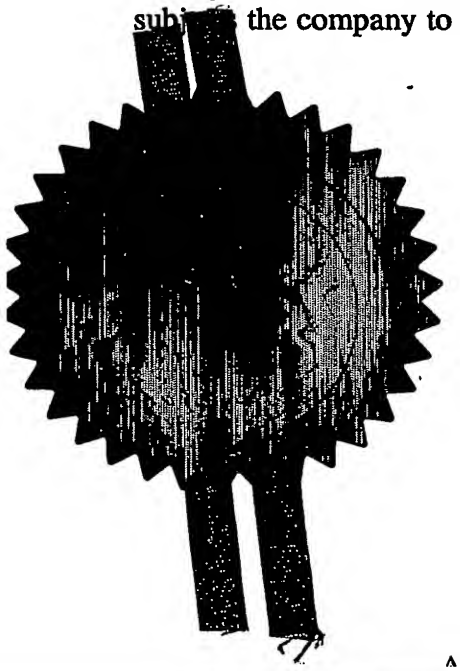

Signed Stephen Hordle

Dated 2 May 2003

PCT/EP03/08315

Patents Form 1/77

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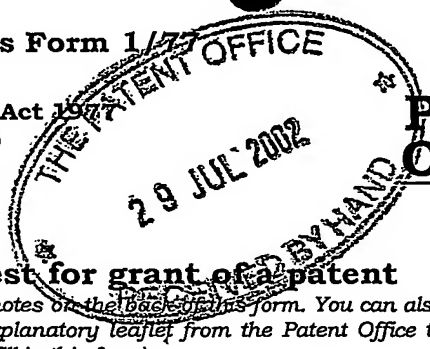

The **Patent Office**

1/77

Request for grant of a patent

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1.	Your reference	4-32596P1	0217499.3
2.	Patent application number *(The Patent Office will fill in this part)*	29 JUL 2002	
3.	Full name, address and postcode of the or of each applicant *(underline all surnames)* 07125487005 Patent ADP number *(if you know it)* If the applicant is a corporate body, give the country/state of its incorporation	NOVARTIS AG LICHTSTRASSE 35 4056 BASEL SWITZERLAND SWITZERLAND	30JUL02 E736935-5 D00524 P01/7700 0.00-0217499.3
4.	Title of invention	Analytical Process	
5.	Name of your agent *(If you have one)* "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* Patents ADP number *(if you know it)*	B.A. YORKE & CO. CHARTERED PATENT AGENTS COOMB HOUSE, 7 ST. JOHN'S ROAD ISLEWORTH MIDDLESEX TW7 6NH 1800001	

6.	If you are declaring priority from one ore more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number	Country	Priority application number *(if you know it)*	Date of filing (day/month/year)
7.	If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application		Number of earlier application	Date of filing (day/month/year)
8.	Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *(see note (d))*	Yes		

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9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	8
Claim(s)	3
Abstract	1
Drawing(s)	1 + 1

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10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application

Signature B.A. Yorke & Co. Date **29 July 2002**

12. Name and daytime telephone number of person to contact in the United Kingdom **Mrs. E. Cheetham**
020 8560 5847

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Case 4-32596 P1

DUPLICATE

ANALYTICAL PROCESS

Field of the Invention

The present invention provides a method to detect volatile components in a sample by headspace gas chromatography, wherein said method comprises dissolving or dispersing a sample in at least one ionic liquid and volatilizing the volatile components of the sample.

Background of the Invention

The purity of a compound may affect many physical and chemical properties of the compound, for example, the electrical conductivity, luminescence, capacity for polymerization, and stability. Even impurities present in very low amounts, for example, 10^{-2} to 10^{-9}, may deleteriously affect the properties of a compound or the analysis of the compound, and thus, prevent a compound from being used in its intended field. This is especially true in the pharmaceutical industry where impurities in a drug compounds may decrease bioavailability of the drug, and prevent the Food and Drug Administration from either approving the drug, or approving a process to prepare the drug.

Volatile constituents of samples have been determined by gas chromatography (GC) advantageously for the following reasons: (i) GC provides in a single analysis information about many impurities, not just a single one, particularly because it gives very sharp separations, which allows one to analyze for impurities that differ only slightly in properties, such as isomers; (ii) sensitive detectors allow one to detect impurities at very low concentrations; (iii) headspace gas chromatography can be combined with spectroscopic instruments for identification of separated compounds; and (iv) accumulation techniques can be used independently to reduce further the minimum detectable concentration.

Other methods of gas analysis exist, such as mass spectrometry, IR spectroscopy and UV spectroscopy, for the determination of compounds in their vapor state in the presence of liquids and solids. However, these methods are often insufficiently sensitive, and when several materials are present in the vapor phase, they give inextricably complex results, since only the sum of the components can be measured.

Headspace gas chromatography (HSGC) generally consists of a static or dynamic headspace gas sampling device, which may be manually operated or automated, and a gas chromatograph. The headspace sampling device variants allow for selectively volatilizing the

volatile components of a test sample. A representative fraction or the total amount of the volatile components is carried into the chromatographic column mounted in the oven of a gas chromatograph. Several variants of technical realizations are commercially available or can be handcrafted. Static headspace sampling devices apply, for example, balanced pressure injection, loop-injection or syringe injection. In a first step, dynamic headspace sampling device usually, but not exclusively, preconcentrate a representative fraction or the total amount of the volatile components of the test sample in a trap. In the second step, a representative fraction or the total amount of the preconcentrated volatile components of the test sample is then carried from the trap into the chromatographic column mounted in the oven of a gas chromatograph. A flow of carrier gas carries the volatile components through the chromatographic column where they are separated. The separated components enter a detector, which determines the concentration or mass flow of the components in the carrier gas.

Ionic liquids have been used as solvents for a number of reactions, for example, Friedel-Crafts reactions (Adams, C. J., et al., *Chemistry Communications*, 1998, pgs. 2097-2098; isomerisation of fatty acid derivatives (WO 98/07679, and U.S. Patent No. 6,255,504); dimerization, co-dimerization and oligomerization of olefins (U.S. Patent Nos. 5,550,306, and 5,104,840); Diels-Alder reactions (Earle, M. J., et al., *Green Chemistry*, 1999, vol. 1, pgs. 23-25); and hydrogenation reactions (Fisher, T., et al. Tetrahedron Letters, 1999, vol. 40, pgs. 793-794).

Disadvantages associated with using conventional solvents in headspace gas chromatography are (i) high vapor pressure which causes broad solvent peaks in the chromatogram; (ii) limited temperature range of application; and (iii) carry over from oonsecutive injections in the gas chromatograph. Therefore, it would be desirable to have a method that allows for the detection, and/or quantification, and/or identification of volatile components in a test sample without the disadvantages arising from conventional solvents.

Summary of the Invention

The invention provides a method to detect volatile components in a sample by headspace gas chromatography, wherein said method comprises dissolving or dispersing a sample in at least one ionic liquid and volatilizing the volatile components of the sample. Preferably, the ionic liquid has essentially no vapor pressure.

According to another aspect the invention provides a method to quantify and identify volatile components in a sample by headspace gas chromatography, wherein said method comprises dissolving or dispersing a sample in at least one ionic liquid and volatilizing the volatile components of the sample.

The advantages of the method of the invention include that: (i) ionic liquids have essentially no vapor pressure, thus, no interfering solvent peaks are generated by the ionic liquids; (ii) less overpressure is generated inside a sample vial containing an ionic liquid as compared to a conventional solvent, which reduces seal failure and leakage of the vial; (iii) ionic liquids have high thermal stability which allows the application range of headspace gas chromatograph to be expanded; (iv) the high thermal stability of ionic liquids allows the detection limit of headspace gas chromatograph to be expanded; and (v) headspace gas chromatography allows for detection of volatile impurities in ionic liquids.

Brief Description of the Drawings

Fig. 1 is a headspace gas chromatogram showing residual solvents in 1-ethyl-3-methyl-imidazolium trifluoromethanesulfonate, 1-ethyl-3-methyl-imidazolium bis-(trifluoromethanesulfonyl)-amide, dimethylsulfoxide, and N,N-dimethylacetamide.ethanol.

Description of the Invention

The method of the invention is used to detect volatile components in a sample by headspace gas chromatography, wherein said method comprises dissolving or dispersing a sample in at least one ionic liquid and volatilizing the volatile components of the sample. In another embodiment of the invention, the method of the invention is used to quantify and identify volatile components in a sample by headspace gas chromatography, wherein said method comprises dissolving or dispersing a sample in at least one ionic liquid and volatilizing the volatile components of the sample. The volatile components of a sample can be analyzed by the method of the invention.

As used herein, "gas chromatography or "gas chromatographic" includes gas-liquid chromatography and gas-solid chromatography. As used herein, "headspace" includes static headspace techniques and dynamic headspace techniques. Headspace gas

chromatography and gas chromatography are known to those skilled in the art of analytical chemistry.

As used herein, "samples" includes gas, liquid, and solid materials. A combination of materials may also be used. Examples of samples which may be used in the method of the invention include, but are not limited to, liquid samples, such as drinking water, beverages, vegetable oils, mineral oils, etc; samples containing a liquid and a solid, such as blood, milk, sewage, polymer dispersions, etc; solid materials which give homogenous solutions, such as soluble polymers, inorganic salts, etc; insoluble solid samples, such as high molecular weight olefins, foodstuffs, fruits, tobacco, spices, etc; air, dioxins, PCB's, and pharmaceutical compounds.

Ionic liquids are characterized by a positively charged cation and a negatively charged anion. Generally, any molten salt or mixture of molten salts is considered an ionic liquid. Ionic liquids typically have essentially no vapor pressure, good heat transfer characteristics, are stable over a wide temperature range, and are capable of dissolving a wide range of material in high concentrations. As used herein, "essentially no vapor pressure" means that the ionic liquid exhibits a vapor pressure of less than about 1 mm/Hg at 25°C, preferably less than about 0.1 mm/Hg at 25°C.

With respect to the type of ionic liquid, a wide variety of possibilities exist. However, the preferred ionic liquids are liquid at relatively low temperatures, for example, below the melting point of the compound or sample to be analyzed. Preferably, the ionic liquid has a melting point of less than 250°C, more preferably less than 100°C. Most preferably, the ionic liquid has a melting point of less than 30°C and is a liquid at room temperature.

With regard to viscosity of the ionic liquid, it is important that the viscosity of the ionic liquid not be too high to prevent a homogeneous solution or dispersion of a compound or sample in an ionic liquid. Preferably, the ionic liquid has a viscosity of less than 500 centipoise (cP), more preferably, less than 300 cP, and most preferably less than 100 cP, as determined at 25°C.

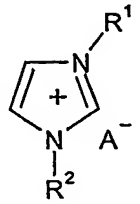
The cation present in the ionic liquid can be a single species or a plurality of different species. Both of these embodiments are intended to be embraced, unless otherwise specified, by the use of the singular expression "cation." The cations of the ionic liquid

include organic and inorganic cations. Examples of cations include quaternary nitrogen-containing cations, phosphonium cations, and sulfonium cations.

The quaternary nitrogen-containing cations are not particularly limited and embrace cyclic, aliphatic, and aromatic quaternary nitrogen-containing cations. Preferably, the quaternary nitrogen-containing cation is an n-alkyl pyridinium, a dialkyl imidazolium, or an alkylammonium of the formula $R'_{4-X}NH_X$ wherein X is 0-3 and each R' is independently an alkyl group having 1 to 18 carbon atoms. It is believed that unsymmetrical cations can provide for lower melting temperatures. The phosphonium cations are not particularly limited and embrace cyclic, aliphatic, and aromatic phosphonium cations. Preferably, the phosphonium cations include those of the formula $R''_{4-X}PH_X$ wherein X is 0-3, and each R'' is an alkyl or aryl group such as an alkyl group having 1 to 18 carbon atoms or a phenyl group. The sulfonium cations are not particularly limited and embrace cyclic, aliphatic, and aromatic sulfonium cations. Preferably, the sulfonium cations include those of the formula $R'''_{3-X}SH_X$ wherein X is 0-2 and each R''' is an alkyl or aryl group such as an alkyl group having 1 to 18 carbon atoms or a phenyl group. Preferred cations include 1-hexylpyridinium, ammonium, imidazolium, 1-ethyl-3-methylimidazolium, 1-butyl-3-methylimidazolium, phosphonium, and N-butylpyridinium.

The anion used in the ionic liquid is not particularly limited and includes organic and inorganic anions. Generally the anion is derived from an acid, especially a Lewis acid. The anions are typically metal halides as described in more detail below, boron or phosphorus fluorides, alkylsulfonates including fluorinated alkyl sulfonates such as nonafluorobutanesulfonate, and carboxylic acid anions such as trifluoroacetate and heptafluorobutanoate. The anion is preferably Cl^-, Br^-, NO_2^-, NO_3^-, $AlCl_4^-$, BF_4^-, PF_6^-, CF_3COO^-, $CF_3SO_3^-$, $(CF_3SO_2)_2N^-$, OAc^-, $CuCl_3^-$, $GaBr_4^-$, $GaCl_4^-$, and SbF_6^-.

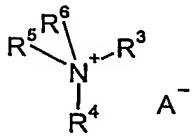
Examples of ionic liquids include, but are not limited to, imidazolium salts, pyridium salts, ammonium salts, phosphonium salts, and sulphonium salts. Preferred imidazolium salts have formula (I)



(I)

wherein R^1 and R^2 are independently selected from the group consisting of a C_1-C_{18} aliphatic group and a C_4-C_{18} aromatic group; and A^- is an anion.

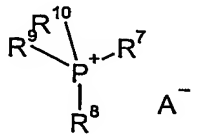
Preferred ammonium salts have formula (II)



(II)

wherein R^3, R^4, R^5 and R^6 are independently selected from the group consisting of a C_1-C_{18} aliphatic group and a C_4-C_{18} aromatic group; and A^- is an anion. Preferably, R^3, R^4, R^5 and R^6 are independently selected from the group consisting of ethyl, propyl and butyl.

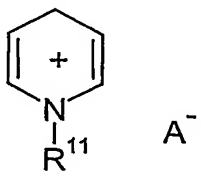
Preferred phosphonium salts have formula (III)



(III)

wherein R^7, R^8, R^9 , and R^{10} are independently selected from the group consisting of a C_1-C_{18} aliphatic group and a C_4-C_{18} aromatic group; and A^- is an anion. Preferably, R^7, R^8, R^9 , and R^{10} are independently selected from the group consisting of ethyl and butyl.

Preferred pyridinium salts have formula (IV)



(IV)

wherein R^{11} is selected from the group consisting of a C_1-C_{18} aliphatic group and a C_4-C_{18} aromatic group; and A^- is an anion. Preferably R^{11} is ethyl or butyl.

Specific examples of ionic liquids include, but are not limited to, 1-butyl-3-methylimidazolium hexafluorophosphate, 1-hexyl-3-methylimidazolium hexafluorophosphate, 1-octyl-3-methylimidazolium hexafluorophosphate, 1-decyl-3-methylimidazolium hexafluorophosphate, 1-dodecyl-3-methylimidazolium hexafluorophosphate, 1-ethyl-3-methylimidazolium bis((trifluoromethyl)sulphonyl)amide, 1-hexyl-3-methylimidazolium bis((trifluoromethyl)sulphonyl)amide, 1-hexylpyridinium tetrafluoroborate, 1-octylpyridinium tetrafluoroborate, 1-butyl-3-methylimidazolium tetrafluoroborate, 1-methy-3-ethyl imidazolium chloride, 1-ethyl-3-butyl imidazolium chloride, 1-methy-3-butyl imidazolium chloride, 1-methy-3-butyl imidazolium bromide, 1-methy-3-propyl imidazolium chloride, 1-methy-3-hexyl imidazolium chloride, 1-methy-3-octyl imidazolium chloride, 1-methy-3-decyl imidazolium chloride, 1-methy-3-dodecyl imidazolium chloride, 1-methy-3-hexadecyl imidazolium chloride, 1-methy-3-octadecyl imidazolium chloride, 1-methy-3-octadecyl imidazolium chloride, ethyl pyridinium bromide, ethyl pyridinium chloride, ethylene pyridinium dibromide, ethylene pyridinium dichloride, butyl pyridinium chloride, and benzyl pyridinium bromide.

Preferred ionic liquids are 1-octyl-3-methyl-imidazolium hexafluorophosphate, 1-hexyl-3-methy-imidazolium hexafluorophosphate, 1-butyl-3-methyl-imidazolium hexafluorophosphate, 1-butyl-3-methyl-imidazolium tetrafluoroborate, 1-butyl-3-methyl-imidazolium trifluoromethanesulfonate, 1-ethyl-3-methyl-imidazolium trifluoromethanesulfonate, and 1-ethyl-3-methyl-imidazolium bis-(trifluoromethanesulfonyl)-amide. Most preferably, the ionic liquid is 1-octyl-3-methyl-imidazolium hexafluorophosphate or 1-hexyl-3-methy-imidazolium hexafluorophosphate.

A mixture of ionic liquids, including binary ionic liquids, may also be used. The ionic liquids can be prepared by any of the methods described in the art.

The sample or compound to be analyzed by headspace gas chromatography is dissolved or dispersed, preferably dissolved, in the ionic liquid. The amount of ionic liquid is not particularly limited. Preferably, about 1 to about 100 mg of a sample or compound to be analyzed is dissolved or dispersed in about 0.1 to about 5 ml. of ionic liquid.

The following non-limiting examples illustrate further aspects of the method of the invention.

Examples

Headspace Gas Chromatography Analysis of Volatile Solvents.

Four vials were prepared which each contained 39.5 µg ethanol, 45.0 µg ethyl acetate, 39.0 µg cyclohexane, and 43.5 µg toluene, which was dissolved in 0.1 ml of either one of the following ionic liquids: 1-ethyl-3-methyl-imidazolium trifluoromethanesulfonate or 1-ethyl-3-methyl-imidazolium bis-(trifluoromethanesulfonyl)-amide, or one of the following conventional solvents: dimethylsulfoxide or N,N-dimethylacetamide.ethanol.

The chromatograms were obtained using Agilent Equipment (Headspace Autosampler 7694, a Gas chromatograph 5890 with FID and a DB-624 column). The vials were equilibrated for 20 min at 120 °C prior to analyzing the gas phase. GC-temperature program was from 40 °C (1 min), raising with 10 °C/min to 240 °C and hold for 3 minutes at 240 °C. Carrier gas was Helium at a pressure of 25 kPa.

The chromatogram of each sample is shown in the overlay plot of Fig. 1. The results in Fig. 1 clearly show that ionic liquids may be used in place of conventional solvents in headspace gas chromatography. In addition, Fig. 1 shows that ionic liquids due to their high temperature stability allow for an expanded application range that includes the actual conventional solvent peaks.

The advantages of the method of the invention include that: (i) ionic liquids have essentially no vapor pressure, thus, no interfering solvent peaks are generated by the ionic liquids; (ii) less overpressure is generated inside a sample vial containing an ionic liquid as compared to a conventional solvent, which reduces seal failure and leakage of the vial; (iii) ionic liquids have high thermal stability which allows the application range of headspace gas chromatograph to be expanded; (iv) the high thermal stability of ionic liquids allows the detection limit of headspace gas chromatograph to be expanded; and (v) headspace gas chromatography allows for detection of volatile impurities in ionic liquids.

While the invention has been described with particular reference to certain embodiments thereof, it will be understood that changes and modifications may be made by those of ordinary skill within the scope and spirit of the following claims:

WHAT IS CLAIMED IS:

1. Use of ionic liquids as solvents in headspace gas chromatography.

2. A method to detect volatile components in a sample by headspace gas chromatography, wherein said method comprises dissolving or dispersing a sample in at least one ionic liquid and volatilizing the volatile components of the sample.

3. A method to quantify and identify volatile components in a sample by headspace gas chromatography, wherein said method comprises dissolving or dispersing a sample in at least one ionic liquid and volatilizing the volatile components of the sample.

4. The method according to Claim 1 wherein the ionic liquid has a melting point of less than 250°C.

5. The method according to Claim 4 wherein the ionic liquid has a melting point of less than 100°C.

6. The method according to Claim 5 wherein the ionic liquid has a melting point of less than 30°C.

7. The method according to Claim 1 wherein the ionic liquid has essentially no vapor pressure.

8. The method according to Claim 7 wherein the ionic liquid has a vapor pressure of less than about 1 mm/Hg at 25°C.

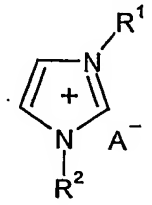
9. The method according to Claim 8 wherein the ionic liquid has a vapor pressure of less than about 0.1 mm/Hg at 25°C.

10. The method according to Claim 1 wherein the anion of the ionic liquid is selected from the group consisting of Cl^-, Br^-, NO_2^-, NO_3^-, $AlCl_4^-$, BF_4^-,.PF_6^-,CF_3COO^-, $CF_3SO_3^-$, $(CF_3SO_2)_2N^-$, OAc^-, $CuCl_3^-$, $GaBr_4^-$, $GaCl_4^-$, and SbF_6^-.

11. The method according to Claim 1 wherein the cation is selected from the group consisting of pyridinium, ammonium, imidazolium, phosphonium, and sulphonium.

12. The method according to Claim 1 wherein the ionic liquid is selected from the group consisting of an imidazolium salt, pyridium salt, ammonium salt, phosphonium salt, and sulphonium salt.

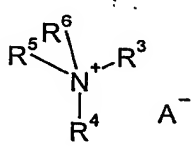
13. The method according to Claim 12 wherein the imidazolium salt has formula (I)



(I)

wherein R^1 and R^2 are independently selected from the group consisting of a C_1-C_{18} aliphatic group and a C_4-C_{18} aromatic group; and A^- is an anion.

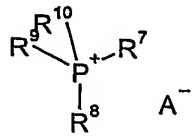
14. The method according to Claim 12 wherein the ammonium salt has formula (II)



(II)

wherein R^3, R^4, R^5 and R^6 are independently selected from the group consisting of a C_1-C_{18} aliphatic group and a C_4-C_{18} aromatic group; and A^- is an anion.

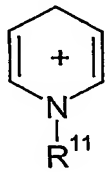
15. The method according to Claim 12 wherein the phosphonium salt has formula (III)



(III)

wherein R^7, R^8, R^9 , and R^{10} are independently selected from the group consisting of a C_1-C_{18} aliphatic group and a C_4-C_{18} aromatic group; and A^- is an anion.

16. The method according to Claim 12 wherein the pyridinium salt has formula (IV)



(IV)

wherein R^{11} is selected from the group consisting of a C_1-C_{18} aliphatic group and a C_4-C_{18} aromatic group; and A^- is an anion.

17. The method according to Claim 1 wherein the ionic liquid is selected from the group consisting of 1-butyl-3-methylimidazolium hexafluorophosphate, 1-hexyl-3-methylimidazolium hexafluorophosphate, 1-octyl-3-methylimidazolium hexafluorophosphate, 1-decyl-3-methylimidazolium hexafluorophosphate, 1-dodecyl-3-methylimidazolium hexafluorophosphate, 1-ethyl-3-methylimidazolium bis((trifluoromethyl)sulphonyl)amide, 1-hexyl-3-methylimidazolium bis((trifluoromethyl)sulphonyl)amide, 1-hexylpyridinium tetrafluoroborate, 1-octylpyridinium tetrafluoroborate, 1-butyl-3-methylimidazolium tetrafluoroborate, 1-methy-3-ethyl imidazolium chloride, 1-ethyl-3-butyl imidazolium chloride, 1-methy-3-butyl imidazolium chloride, 1-methy-3-butyl imidazolium bromide, 1-methy-3-propyl imidazolium chloride, 1-methy-3-hexyl imidazolium chloride, 1-methy-3-octyl imidazolium chloride, 1-methy-3-decyl imidazolium chloride, 1-methy-3-dodecyl imidazolium chloride, 1-methy-3-hexadecyl imidazolium chloride, 1-methy-3-octadecyl imidazolium chloride, 1-methy-3-octadecyl imidazolium chloride, ethyl pyridinium bromide, ethyl pyridinium chloride, ethylene pyridinium dibromide, ethylene pyridinium dichloride, butyl pyridinium chloride, benzyl pyridinium bromide, and mixtures thereof.

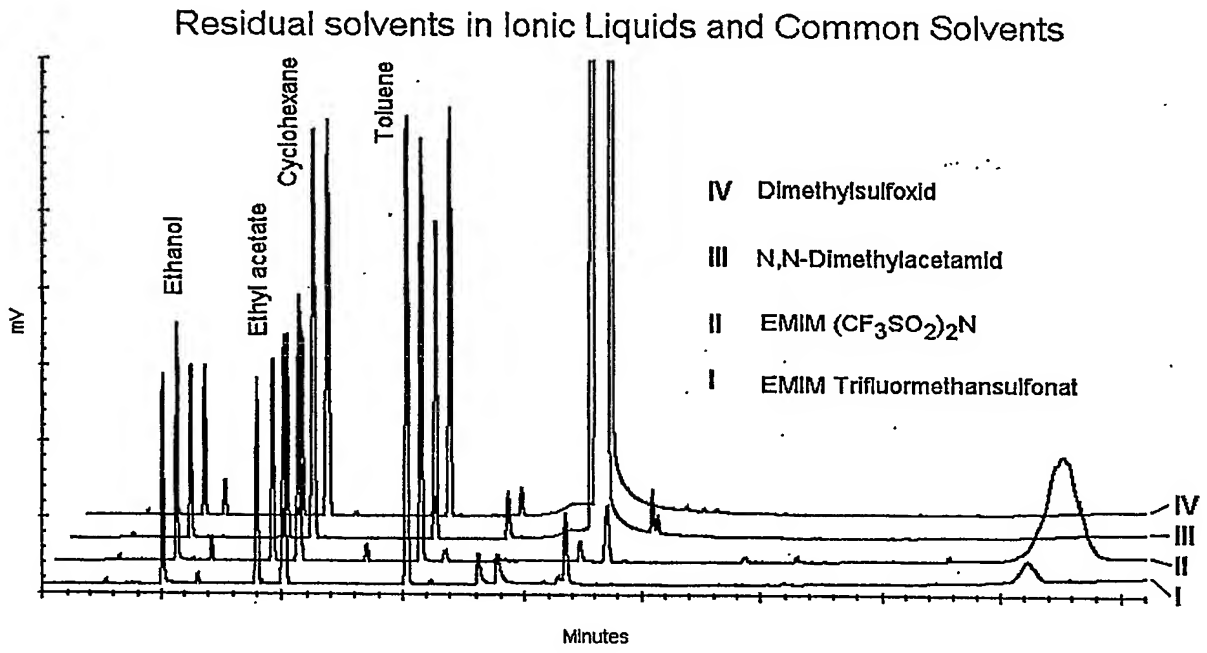
18. The method according to Claim 17 wherein the ionic liquid is selected from the group consisting of 1-octyl-3-methyl-imidazolium hexafluorophosphate, 1-hexyl-3-methy-imidazolium hexafluorophosphate, 1-butyl-3-methyl-imidazolium hexafluorophosphate, 1-butyl-3-methyl-imidazolium tetrafluoroborate, 1-butyl-3-methyl-imidazolium trifluoromethanesulfonate, 1-ethyl-3-methyl-imidazolium trifluoromethanesulfonate, and 1-ethyl-3-methyl-imidazolium bis-(trifluoromethanesulfonyl)-amide.

19. The method according to Claim 1 wherein the sample is a pharmaceutical compound.

Abstract of the Disclosure

A method to detect volatile components in a sample by headspace gas chromatography, wherein said method comprises dissolving or dispersing a sample in at least one ionic liquid and volatilizing the volatile components of the sample. According to another aspect the invention provides a method to quantify and identify volatile components in a sample by headspace gas chromatography. The advantages of the method of the invention include that: (i) ionic liquids have essentially no vapor pressure, thus, no interfering solvent peaks are generated by the ionic liquids; (ii) less overpressure is generated inside a sample vial containing an ionic liquid as compared to a conventional solvent, which reduces seal failure and leakage of the vial; (iii) ionic liquids have high thermal stability which allows the application range of headspace gas chromatograph to be expanded; (iv) the high thermal stability of ionic liquids allows the detection limit of headspace gas chromatograph to be expanded; and (v) headspace gas chromatography allows for detection of volatile impurities in ionic liquids.

Figure 1


Residual solvents in Ionic Liquids and Common Solvents
mV
Ethanol
Ethyl acetate
Cyclohexane
Toluene
IV Dimethylsulfoxid
III N,N-Dimethylacetamid
II EMIM $(CF_3SO_2)_2N$
I EMIM Trifluormethansulfonat
IV
III
II
I
Minutes